

Pea Wilts and Root Rots



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"Pea sick" fields are the result of the accumulation of pea disease fungi in the soil. There are several distinct organisms involved. Page 3

Wilt and near-wilt, once introduced in certain types of soil, increase gradually and stay indefinitely. The wilt fungi enter the young roots and travel up the water vessels. A plant once infected never recovers. Page 3

Wilt can be controlled only by the use of wilt-resistant varieties, the more important of which are listed. No control for near-wilt is known but it is hoped that resistant varieties will eventually be developed. Page 10

Root rots attack and cause distinct lesions on the outer portions of the roots and lower stems. Plants mildly affected sometimes produce a fairly good yield. *Aphanomyces* root rot develops most aggressively in low, poorly drained soil and in heavier soils which are high in water-holding capacity. Page 11

Wilt-resistant varieties are no more resistant to root rots than are the wilt-susceptible varieties. Root rots can be reduced, however, by selecting well drained fields, providing readily available plant food through application of fertilizers, and systematic rotation of peas with other crops. Page 14

Pea Wilts and Root Rots

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“**P**EA-SICK” soils have long been a hazard in growing this crop on many Wisconsin farms. In many cases even long rotation with other crops has not satisfactorily solved the problem. Several distinct diseases may be involved. The most serious of these, *wilt*, can be controlled only by the use of wilt-resistant varieties. The other troubles, *near-wilt* and *root rots*, unfortunately are not remedied in this manner but much can be done to keep them in check by the proper selection of fields and management of the crop.

Wilt Causes Heavy Losses

In recent years this disease¹ has caused heavy losses where susceptible varieties were grown upon “wilt-sick” soil. It was first clearly recognized in 1924 although it probably had been present in our pea soils for a long time before that. It is now known to occur in some eleven states extending from Maryland to Washington.

It is not always easy to differentiate wilt from root rots but it does have certain distinct characteristics. One point to be kept in mind is that some standard varieties, if pure strains, are completely resistant while others are completely susceptible to wilt. Green Admiral, Yellow Admiral, Green Giant, and Horal are among those which are resistant while Perfection, Surprise and Gem are susceptible. Alaska stocks vary. Most older stocks have a high percentage of susceptible plants while some have various percentages of resistant plants. Highly resistant strains of Alaska and Alcross have been developed which are as completely resistant as the naturally resistant varieties. A more complete list of varieties is given on page 9.

¹ Caused by a fungus, *Fusarium oxysporum* f. *pea* race 1.

When wilt appears in a field of susceptible peas it usually develops in roughly circular spots a few feet to several rods in diameter. If the plants are examined soon after these spots appear the margins of the leaves will be found to curve downward. The plants become a pale yellow-green and their growth is stunted. The stem near the ground sometimes becomes slightly swollen and brittle, while the leaves continue to wither and shrivel. Eventually the plant dies completely. The rate at which these changes occur depends upon the amount of fungus in the soil and the kind of weather. Wilt is favored by warm soil temperature and thus does not appear usually until after the middle of May. Mildly affected plants may produce some pods which always ripen prematurely and contain berries of poor quality.

If these wilted plants are not also affected by root rots the roots appear quite healthy even after the disease is well along in the tops. The fungus, however, has entered through the young roots and grown up gradually through the water vessels. If one slices off the outside of the lower stem and the main root of a diseased plant, the water vessels often show as an orange brown streak which is helpful in determining wilt. It should be remembered, however, that plants affected with this disease do not always show this discoloration. Furthermore the root rot fungi in their later stages of disease production also commonly cause a discoloration somewhat like this, and near-wilt has a brick red streak. Thus the other characters of the disease as described above are more important in defining wilt. Do not lose sight of the other important fact that "wilt" plants may also be more or less affected by root rot diseases (see page 10).

Rate of Spread of the Wilt Organism

Where a soil favorable to the wilt fungus becomes infested, definite steps in the progress of the fungus may be seen. Infection may start from a diseased seed or from soil carried in from a neighboring "wilt" field. Yet unless there is a large amount of the fungus in any one spot, susceptible pea varieties may produce a normal crop with no signs of the disease the season during which the fungus is introduced. However, it grows in the soil, multiplying on dead

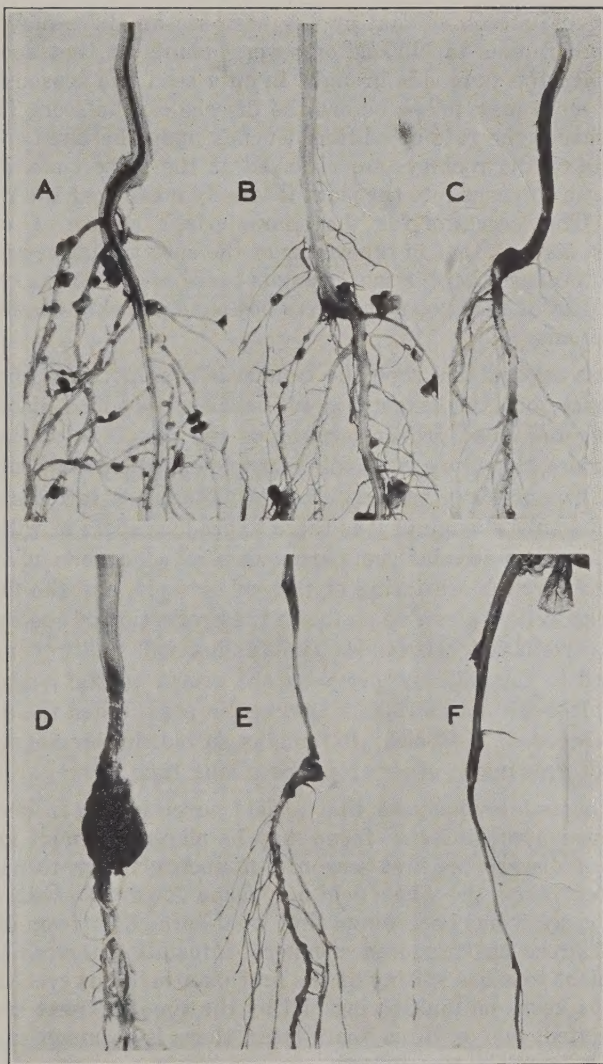


FIG. 1—PEA WILT AND ROOT ROTS

A. *Wilt*. Note that the root system looks quite as healthy as that of the healthy plant (B). The discoloration is internal and confined to the vessels; it is usually orange brown but is not always present. The distinctive features of wilt are to be found on the above ground parts (See discussion in the text). C. *Fusarium root rot*. The region just above the seed is most susceptible. The lesion is reddish brown or chocolate-colored. Sometimes the water vessels are colored, usually brick red. D. *Rhizoctonia root rot*. The lesion is usually reddish-brown, sunken, and eroded. The stem may be completely girdled. E., F. *Aphanomyces root rot*. The outer portions of roots and lower stem becomes softened, water-soaked, and slightly discolored. When the plant is pulled, most of the root system often sloughs off leaving only the central fiber-like core of water vessels. Secondary organisms sometimes cause a reddening of the vessels for some distance above the lesion.

roots and stems, so that by the next season there may be enough fungus to kill one or several plants at that spot.

When the fungus is brought in on a seed two seasons or even more may follow before the disease can be seen. This is because the rate of wilting depends upon the number of points of the root system attacked at the same time, and because entrance into the plant is largely made near the root tips. This accounts for the characteristic nature of wilt spots, namely, that in the center of the spot wilting is most rapid because there is more fungus there, while on the outside part of the spot plants may be found showing the first symptoms.

Just beyond this zone the fungus is present for a short distance, but the amount is too small to produce disease during the short growing season of the pea. It is obvious, therefore, that the grower may not know his field is infected until two or three seasons after the fungus is introduced, that is, until enough of it is there to produce spots of wilted plants. When sizeable spots are once seen, enlargement and spread through scattering of the soil is rapid, and the field may as well be given up as far as the production of susceptible varieties is concerned. The fungus will multiply and spread in the soil whether peas are grown on the land or not, although not as rapidly as when in peas. When the soil once becomes "wilt-sick" it remains so indefinitely regardless of growing of other crops for a long time.

It sometimes happens that a field never before in peas, but near a wilt-infested farm, may be planted without any sign of disease the first season. But upon planting to peas the next time, the whole field may come down with wilt. In such cases it has been found that wind-borne dust from diseased areas has produced a general infestation though insufficient to cause wilting of the first planting. However the fungus keeps on multiplying and by the time the next crop is planted, two or three years later, there is so much of it that a complete loss follows.

Relation of Soil Type to Wilt

In the region from Waupun southward it is becoming harder to find good pea land free from the wilt fungus or that will remain so for three or four years. The pea soils in

that section are mostly Carrington and Miami silt loams. In the Colby silt loam area including Marshfield, Colby, and Owen, wilt is seldom seen and, where found, makes little or no progress from year to year. The Ashland district, where Superior red clay is the common soil type, has never been known to yield a case of pea wilt.

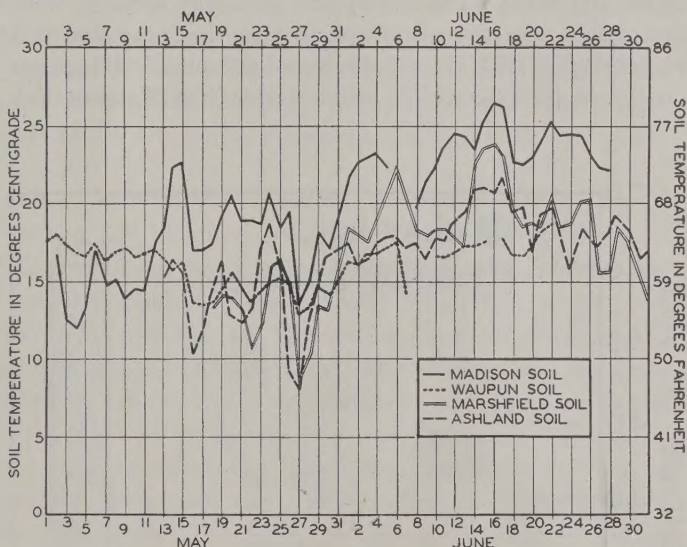


FIG. 2—THE DAILY MEAN TEMPERATURE (AVERAGE OF BI-HOURLY READINGS OF THE SOIL AT TWO INCHES BELOW THE SURFACE)

This was taken during 1932 at four locations in the state. These represent northern, (Ashland), central (Marshfield and Waupun), and southern (Madison) latitude. Wilt appeared at the Waupun station about May 20 and developed rapidly thereafter. Since wilt develops at temperatures of 54° F. and above, it is apparent that the temperatures of northern and central Wisconsin were in this year favorable to wilt development during the pea growing season.

A study of the soil temperatures show that the soil in all these regions is warm enough during the growing season to favor wilt development (See Fig. 2). This was shown by taking soil from an infested field near Waupun to the Marshfield and Ashland Experiment Stations and growing peas on it in 1931 and 1932. Wilt developed in both places in susceptible varieties planted on the Waupun soil.

However the experience of E. J. Delwiche indicated that the wilt fungus does not readily establish itself in the clay soil at Ashland. A small plot of soil was inoculated with cultures of the fungus in 1927 and peas grown on it for two seasons. No appreciable amount of wilt developed so the area was abandoned as a pea wilt plot. General observations in the Carrington and Miami silt loam areas of southern Wisconsin indicate that if the wilt organism once gets started in the soil it stays indefinitely and gradually spreads. Wilt-susceptible peas were again planted on the inoculated plot at Ashland in 1931. No wilt developed although it did appear nearby on peas planted in soil brought from Waupun. Soil

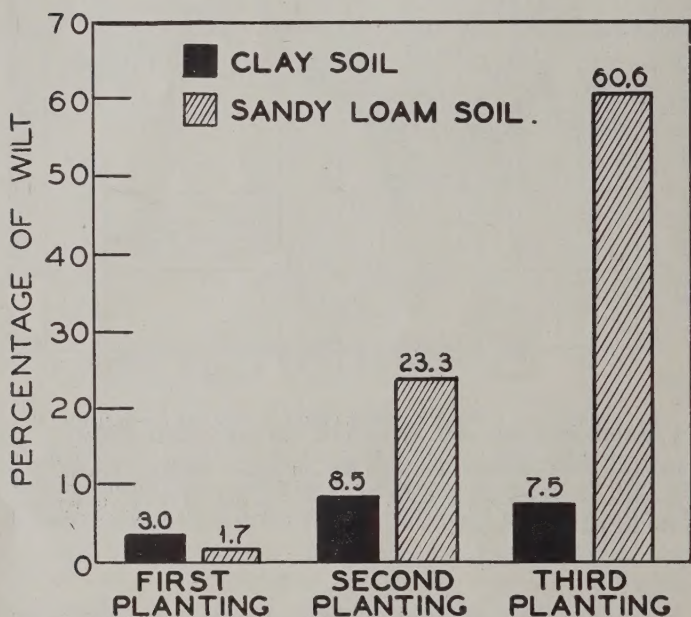


FIG. 3—PEA WILT BECOMES ESTABLISHED MORE RAPIDLY IN SOME SOILS THAN IN OTHERS

Equal amounts of soil from an infested field were mixed with a heavy clay soil from Ashland and a sandy loam soil from near Madison. The percentage of wilted plants steadily increased in successive plantings in the sandy loam soil but it remained quite low in the clay soil.

from the inoculated plot was transferred to the greenhouse the following winter; and peas were grown upon it repeatedly without any wilt whatsoever, further indicating that the fungus had completely disappeared.

Further studies were made to compare the establishment of wilt in this soil with a sandy loam soil from the University Farm at Madison. With 10 parts of each of these soils was thoroughly mixed one part of soil from an infested field of Carrington silt loam near Waupun. Three successive plantings of susceptible Perfection peas were made in the greenhouse under favorable conditions for wilt development. The results are shown graphically in Figure 3.

Resistant Varieties Will Control Wilt

When wilt was first recognized it was evident that certain varieties of peas withstood this disease while others succumbed completely. This is true for canning, garden, and field peas. (See Fig. 4). The stocks of Alaska show varying percentages of resistant plants. Alcross originally contained about 50 per cent resistant plants. By growing Alcross and partly resistant strains of Alaska on "wilt sick" soil to eliminate susceptible plants, highly resistant stocks have been secured. Since good stocks of varieties like Perfection and Surprise contain few or no plants of good type which are resistant, it was necessary to cross plants of these varieties with resistant plants of other varieties and select from such crosses for resistance combined with the desired type. In this manner Wisconsin Perfection, Wisconsin Early Sweet, Penin, and Merit have been produced.

Resistant varieties are equally resistant to all strains of the wilt fungus so far collected from a wide range of localities. However, it must be clearly understood that wilt-susceptible and wilt-resistant varieties are both subject to near-wilt and root rot diseases. The chance of developing varieties resistant to root rots at present seems to be remote. Therefore it is important that users of wilt-resistant stocks understand that resistance is concerned only with this one disease.

Near-wilt

Near-wilt was distinguished from wilt in 1931. It occurs even more widely than wilt and has been identified in specimens from Wisconsin, Maryland, Delaware, New Hampshire, Massachusetts, Idaho and Montana. It has gradually increased in importance in Wisconsin and will probably continue to do so since it attacks all the desirable wilt-resistant varieties.

The causal fungus² is closely related to and has much in common with that of wilt. For practical purposes near-wilt differs from wilt chiefly in the facts that (1) it affects wilt-resistant varieties; (2) the disease develops more slowly; and (3) the discoloration of the water vessels is brick-red rather than orange brown and is more likely to run up the entire plant.

Since the near-wilt develops more slowly and in fact has a high optimum temperature, it is of relatively little importance on Alaskas or on early planted sweets. It does its damage in the late-planted Perfections or in still longer seasoned large-berried sweets, and therefore may be an important factor in tapering off yields during the last 2 or 3 weeks of the canning season.

The only hope of near-wilt control is through disease resistance. Some resistance has been found in a few wilt-resistant varieties such as Horal and Roger's K. This resistance is not as complete nor is it inherited as simply as wilt resistance. Definite progress is being made, however, in a joint effort by the Departments of Agronomy and Plant Pathology toward the development of suitable near-wilt resistant types.

Several Types of Root Rot

Several types of root rot are caused by distinct fungi. They differ from wilt and near-wilt in that the attack of the parasites causes discolored areas most conspicuously upon the outside of the main root and underground stem sometimes extending an inch or more above ground. Wilt, on the

² The near-wilt fungus is *Fusarium oxysporum* f. *psii* race 2.

other hand, causes relatively little external damage to the root system. The various root rots are known by the names of the fungi causing them, such as *Aphanomyces* root rot, *Fusarium* root rot, etc.

Aphanomyces Root Rot³—This is the most important of the pea root rots in Wisconsin. If the root and lower stem of plants in the early stages of the disease are examined, the tissue outside of the water and food conducting cylinder is seen to be softened, watersoaked and slightly discolored. As this decay goes on the finer roots are killed; and when the plant is pulled the upper tap root separates easily from the fine roots, while the central cylinder remains intact and is pulled out as a long fibre-like string. (See Fig. 1). The stem decay often extends one or two inches above ground. The leaves of the plant shrivel progressively upwards, the top is dwarfed and in severe cases the plant collapses and dies.



FIG. 4—RESISTANCE TO THE WILT DISEASE

Two varieties planted on wilt-sick soil near Waupun. In the foreground is BADGER, a susceptible variety, in which all plants died while young. In the background is ROGER'S K, a resistant variety, which produced a healthy normal crop.

The decayed stem and root tissue tends to become darker with age. This color, however, is due partly, if not entirely,

³ This is caused by the fungus, *Aphanomyces euteiches*.

to the invasion of soil fungi incapable of attacking the living plant independently. Such organisms thrive upon the rotted tissue and often give a reddish color to the water vessels. This discoloration is not a direct effect of the root-rot organism but the fact that it is commonly found with root rot is emphasized since it may be the basis of confusion with wilt.

One extremely important point about this and other root rots is that in the beginning the parasites invade the less vital portions of the root. Wilt and near-wilt, on the other hand, promptly enter the central core which is the important channel through which the plant must draw water and mineral food in order to live and grow. A wilt-infected plant never recovers. Root rot infected plants may show a considerable amount of root decay without any visible effect upon the aboveground parts. The most favorable conditions for the disease are soil temperatures of 60° F. or above and high soil moisture. When the fungus is abundant in the soil and these conditions last for a long time, damage is heavy, but if they are of short duration the plants may recover enough to yield well. Thus a field may suffer severely one year from this root rot and in another season produce a good crop. This should not necessarily be interpreted as due to the elimination of the fungus during the intervening period, since the variation may be due to the difference in climate of the two seasons.

In general, *Aphanomyces* root rot is more severe on low, poorly drained areas, and on heavy silt or clay soils, while it is less destructive on soils which drain readily and well and do not tend to waterlog.

Fusarium Root Rot ⁴—This is a widespread disease but it is secondary in importance to *Aphanomyces* root rot. The most susceptible portion of the plant is at the base of the stem in the region of seed attachment. From this point a reddish brown or chocolate-colored lesion progresses upward in the form of a wedge, with the point upward. (Fig. 1). As the lesions increase they become sunken and may girdle the plant in the region of the seed, thus severing the root from the stem. Lesions may also occur on the roots and rot off branch rootlets.

⁴ It is caused by a fungus, *Fusarium martii* var. *pisi*.

When injury occurs early in the life of the plant and the root is severed from the stem, a few white new roots may often be seen coming through the decayed tissue of the underground stem. These may enable the plant to persist a while, but the foliage gradually yellows, growth ceases, and death follows.

Very frequently as the decay progresses the fungus enters the central core containing the water vessels and grows upward sometimes beyond the zone of external decay. Where this occurs, a deep red or reddish brown discoloration of the central tissue is produced. By cutting into the inside one may observe such reddening in some instances a short distance into the above ground stem. Although the lesions are rather distinctive in their early stages, other soil organisms soon enter them thus hastening their disintegration and altering their appearance. These complications often make the disease difficult to distinguish satisfactorily in the field and necessitate laboratory examination.

The tops look like those of any dying plant. Yellowed or dead plants commonly occur, scattered singly throughout the field or in very small patches. These diseased plants often stand out conspicuously because of their yellow color or dried upright foliage. When pulled, the root is found to be rotted off or partially decayed and, upon being sliced into, the interior is often seen to be deeply colored.

Weather conditions affect the severity of the disease for any given year, although it is generally present in some degree every season. High soil temperature is most favorable. Where the spring has been warm or peas planted late, the longer favorable period increases the amount of damage.

Rhizoctonia Root Rot—The *Rhizoctonia* fungus,⁵ causes injury to a wide variety of common farm crops, principally on young seedlings and young potato sprouts. Lesions produced upon the underground stem and roots of pea consist of brown or reddish-brown, sunken and eroded areas. (Fig. 1.) With the use of a hand lens tiny brown threads may be seen running over the surface. The fungus is moderately active at very low temperatures, and much of the seedling injury of earlier spring may be due to it. Germinating seeds

⁵ *Corticium vagum*.

are frequently attacked, thus killing the developing plant before it pushes above ground. Often the seed sends up a new shoot to replace the killed one so that a series of killed shoots may be found coming from one seed. Moderate soil temperatures (60° to 70° F.) provide the best conditions for disease. The fungus has been known to girdle the stem or root and upon reaching the water-conducting cylinder invade and discolor it for some distance up the stem. Rhizoctonia root rot is usually of minor importance in Wisconsin.

Ascochyta Root Rot—During the past few years Ascochyta root rot has been of minor importance in Wisconsin. The current practice of buying seed from the semi-arid western United States no doubt accounts in a large measure for the present relative unimportance of the disease. The fungi responsible are seed-borne, and whereas high percentages of middle western and eastern-grown seed have been found to harbor the parasite, that from the far west is practically free from infection.

Two closely related fungi are involved which cause different lesions on leaves and stems, but their effects upon the underground stem are much alike.⁶ Early symptoms produced by these fungi occur as purplish streaks upon the stem both above and below ground, but more pronounced at the nodes. These streaks enlarge into brown-purplish or almost black splotches which may girdle the entire underground stem and extend several inches above ground. Some invasion of the upper root proper is also often seen. The tissue affected remains firm and smooth for some time. Brown to purplish irregular spots also occur on leaves and pods.

Relation of Soil Fertility to Root Rots

Wilt is not greatly influenced by the amount of usable plant food in the soil. In some cases it seems to develop a little more slowly upon plants that are heavily fertilized but in the end little benefit is derived. The only real solution for wilt lies in the use of resistant varieties. No solution for near-wilt is available as yet but it is hoped that resistant varieties will eventually be developed.

The damage from *Aphanomyces* root rot is apparently cut down, however, by adding readily available fertilizer to

⁶ *Ascochyta pinodella* and *Mycosphaerella pinodes*.

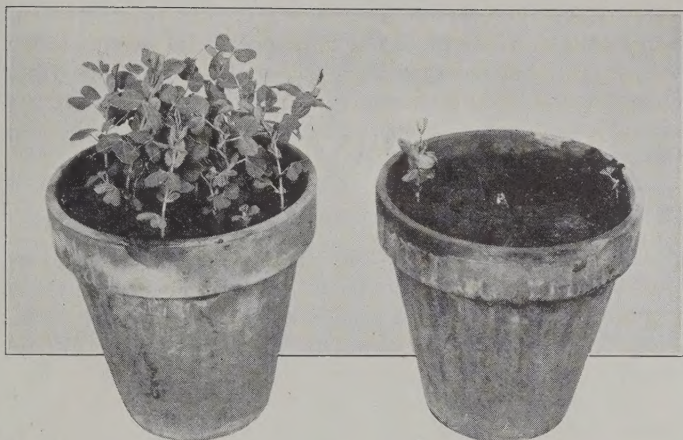


FIG. 5—THE EFFECT OF ADDITION OF FERTILIZER UPON STAND AND HEALTHY GROWTH OF PEAS

The soil in both pots was taken from a field where the crop failed in 1931. A small amount of 4-16-4 fertilizer was added to the soil in the pot at the left before planting. A good stand of healthy plants resulted. In the unfertilized soil the stand was greatly reduced, while the few plants which appeared above ground became stunted and died before they were half grown due to the attack of root-rot organisms.

rather poor soil. Even in Colby silt loam, which is very favorable to root rot, a marked reduction was made in the greenhouse by adding a 4-16-4 fertilizer at the rate of 500 pounds per acre. It is not to be expected that heavy fertilization will completely eliminate root-rot damage, but it is evident that this disease is less destructive to plants which are kept in a good vigorously growing condition.

There is evidence that in some instances, where soils are very lacking in one or more essential nutrients, the weak growth of the plants makes them more susceptible to a variety of soil organisms which do not ordinarily attack vigorous plants. Figure 5 shows the effect of the adding of a small amount of 4-16-4 fertilizer to soil on which the crop turned yellow and the plants became stunted and died without maturing the crop. When tested in the greenhouse pea seeds germinated very poorly in it and the few plants which did appear above ground became stunted and died before they were half grown due to the attack of soil organisms. In the fertilized soil a good stand of healthy plants was grown.

There is every reason for the pea grower to give attention to the fertility of the soil for peas. In most cases in Wisconsin, a balanced fertilizer added at the time of sowing crop will give besides the increased yield, due directly to the available nutrients, a crop which is better able to withstand the attack of root-rotting fungi.

Good Cultural Practices Reduce Root Rots

Although it is not possible as yet to control root rots through disease resistance, much can be done to hold these troubles in check through good crop management. Rotation is essential to prevent the fungi accumulating in the soil. The return of unfermented pea straw refuse, from silage stacks or from the seed thrasher, to soil to be used for peas should be avoided. Soil management should include good drainage and good tilth together with proper fertility to get a good stand and to provide as good growing conditions as the weather will permit.

Good Clean Seed Important

Certain diseases are seed-borne. These include the *Ascochyta* root rots and foliage blights and the bacterial disease of the stems and leaves. Much has been done in recent years to prevent these troubles by the use of seed from the dry regions of the Mountain states, where there is hardly any spread of disease fungi and bacteria to foliage and pods. It has been shown that wilt and near-wilt are also carried with the seed but they are less likely to cause heavy damage to the immediate crop.

While the growing of pea seed in Wisconsin is not necessarily to be discouraged, those who do it should clearly understand the danger of a gradual accumulation of the *Ascochyta* and bacterial blight organisms in a stock increased repeatedly under our climatic conditions. It is by all means dangerous to allow fields blighted by these foliage diseases to pass canning and remain for seed harvest. If an acreage is to be devoted to seed production it is much better to alternate Wisconsin increase with western increase, and give particular attention to seed-borne diseases.